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INTERFACE STANDARDS FOR PUBLIC DATA NETWORKS

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a universal interface that can meet the spectrum of user applications.

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NCS TECHNICAL INFORMATION BULLETIN 79-2

INTERFACE STANDARDS FOR PUBLIC DATA NETWORKS

March 1979

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program which is an element of the overall GSA Federal Standardization Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee, identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of these joint efforts which are contributing to the development of compatible Federal, national, and international standards in the area of data communication interface standards. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs, or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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INTERFACE STANDARDS FOR PUBLIC DATA NETWORKS

HAROLD C. FOLTS

OFFICE OF THE MANAGER NATIONAL COMMUNICATIONS SYSTEM

ABSTRACT

Intense activity over the past several years is leading to a new generation of interface standards for the emerging public data networks being implemented in numerous countries around the world. These new data networks will offer a variety of services including circuit switched, packet switched and leased line to support the rapidly expanding computer and digital communication requirements.

Close liaison is being maintained among ANSI, EIA, Federal Government, ISO, and CCITT activities to produce this new generation of standards. The results of this work are described by this paper. Included are descriptions of the various interface specifications that have been developed and are in the process of being applied around the world. Not all of these standards are fully compatible or are following a convergent course towards a universal interface. Considerable work remains to eliminate differences between the various applications so that it will be possible in the future to come up with a universal interface that can meet the spectrum of user applications.

INTRODUCTION

Throughout the world, many national telecommunication administrations and private operating telecommunication carriers are developing and implementing new digital services for public users. These public data networks will be providing efficient and economical service to the user community to support the rapidly expanding computer communication requirements as well as many other digital transmission requirements. The services

provided will include leased circuit, circuit switching, and packet switching with both virtual call and datagram modes of operation. Accordingly, a new generation of interface standards are required to ensure effective utilization of these emerging services.

The center of the public data networks activity is in the International Telegraph and Telephone Consultative Committee (CCITT) Study Group VII. Diverse inputs are being made from a wide spectrum of interests through the International Organization for Standardization (ISO), national telecommunication administrations, and national standards bodies. In the USA, the American National Standards Institute (ANSI), Electronic Industries Association (EIA), the Federal Government, and the US CCITT Study Group 4 are the centers of activity and liaison. The direction is toward establishment of agreed international standards which are then adopted in the USA for national use. This will result in universal acceptance and application of common standards.

The results of the CCITT work are published as Recommendations. A complete list of the CCITT Recommendations that apply to all aspects of public data networks is provided by table 1. This paper will only cover those that apply to the interface between the user and the network. These are indicated in table 1 by an asterisk.

ARCHITECTURE

Interfaces for data communications have traditionally been specified for operation between data terminal equipment (DTE) and data circuit-terminating equipment (DCE). Figure 1 shows the basic block diagram of an interconnection which is typical to a public data network. For practical purposes, the DCE is generally considered as part of the network as far as the interface

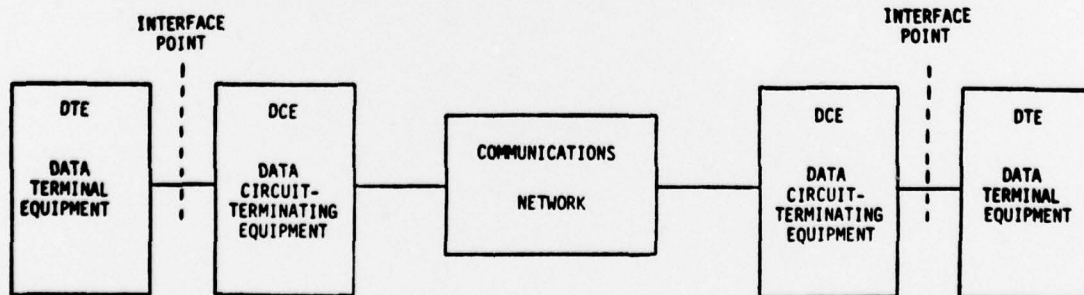


FIGURE 1
TYPICAL INTERCONNECTION

TABLE 1
SERIES X RECOMMENDATIONS - DATA TRANSMISSION
OVER PUBLIC DATA NETWORKS

Number	Title
X.1	International user classes of service in public data networks
X.2	International user facilities in public data networks
*X.3	Packet assembly/disassembly facility (PAD) in a public data network
X.4	General structure of signals of International Alphabet No. 5 code for data transmission over public data networks
*X.10	Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for start-stop transmission services on public data networks
*X.10bis	V.21 - compatible interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for start-stop transmission services on public data networks
*X.21	General purpose interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for synchronous operation on public data networks
*X.21bis	Use on public data networks of data terminal equipments (DTEs) which are designed for interfacing to synchronous V-series modems
X.24	List of definitions of interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) on public data networks
*X.25	Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode on public networks
*X.26	Electrical characteristics for unbalanced double current interchange circuits for general use with integrated circuits equipment in the field of data communications
*X.27	Electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications
X.28	DTE/DCE interface for a start-stop mode data terminal equipment accessing the packet assembly/disassembly facility (PAD) on a public data network situated in the same country
*X.29	Procedures for exchange of control information and user data between a packet mode DTE and a packet assembly/disassembly facility (PAD)
X.30	Standardisation of basic model page-printing machine using International Alphabet No. 5
X.31	Transmission characteristics for start-stop data terminal equipment using International Alphabet No. 5
X.32	Answer-back units for 200- and 300-baud start-stop machines in accordance with Recommendation S.30
X.23	Standardisation of an international text for the measurement of the margin of start-stop machines using International Alphabet No. 5
X.40	Standardisation of frequency shift modulated transmission systems for the provision of telegraph and data channels by frequency division of a primary group
X.50	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks
X.51	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks using 10-bit envelope structure
X.60	Common channel signalling for synchronous data applications - data user part
X.70	Terminal and transit control signalling system for start-stop services on international circuits between asynchronous data networks
X.71	Decentralised terminal and transit control signalling system on international circuits between synchronous data networks
X.92	Hypothetical reference connections for public synchronous data networks
X.95	Network parameters in public data networks
X.96	Call progress signals in public data networks

A complete interface is defined by a number of characteristics. They include the electrical, physical and functional characteristics, as well as the necessary procedures to facilitate transfer of control information and of data across the interface. There are a number of protocols that can be involved in different applications and modes of operation; therefore, a basic architecture has been defined to clearly identify the interface levels so that they may be independently treated. These levels, as shown in figure 2, are described as follows:

Level 1 - Physical, electrical, functional and procedural level used to activate and deactivate the physical link between the DTE and the network.

Level 2 - The link control level for the interchange of data between the DTE and the network, or between DTEs through a transparent network, to provide framing/synchronization control, and error deletion/correction functions for transported information.

Level 3 - The communication control level defines the formatting of information and control procedures used between the DTE and the network for establishment of end-to-end connections and, in the case of packet or message switching networks, for transferring user data through the network. Additional control functions may also be accommodated which are necessary for flow control and accountability. These latter functions, however, may be considered as a separate level (level 4).

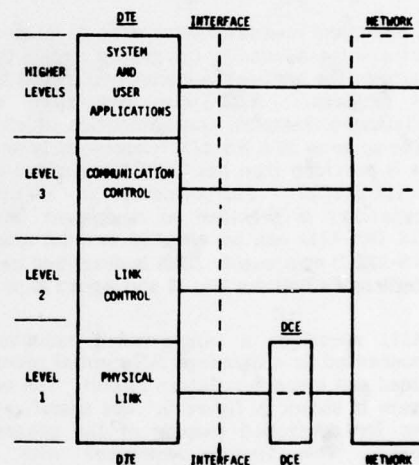


FIGURE 2
ARCHITECTURE OF INTERFACE LEVELS

It is essential that each level be defined and kept independent of each other level in order to achieve maximum flexibility in accommodating a variety of applications. Additionally, the evolution to improved techniques through exploitation of future technology will be greatly facilitated because one level can be changed without interfering with other levels.

FUNCTIONAL, ELECTRICAL, MECHANICAL

The basic elements applicable at level 1 of the architecture are the functional circuits defined by X.24 and the electrical characteristics provided by X.26 and X.27. The mechanical characteristics are specified by ISO in Draft International Standard 4903 which specifies

the interface connector and associate pin assignments for the interchange circuits.

X.24 specifies that the interface is located at a connector between the DTE and DCE as shown in figure 1. This provides the line of demarcation between the equipment. Definitions are provided for two data circuits (T, R), two control circuits (C, I), two timing circuits (S, B), and three common return circuits (G, Ga, Gb). These are summarized in table 2.

TABLE 2
Data Network Interchange Circuits

Interchange circuit designation	Interchange circuit name	Data		Control		Timing	
		From DCE	To DCE	From DCE	To DCE	From DCE	To DCE
G	Signal ground or common return						
Ga	DTE common return				x		
Gb	DCE common return			x			
T	Transmit		x		x		
R	Receive	x		x			
C	Control				x		
I	Indication			x			
S	Signal element timing					x	
B	Byte timing					x	

Two sets of electrical characteristics were developed to efficiently utilize the advancing integrated circuit technology and satisfy the high performance requirements of new digital services. X.26 (also designated V.10) specifies unbalanced electrical characteristics which are essentially the same as EIA RS-423. Considerably better performance is provided than has been experienced with V.28 (EIA RS-232C). Furthermore, an effective transition capability is provided so equipment implementing X.26 (RS-423) can be adapted to interoperate with V.28 (RS-232C) equipment. This is described in EIA Industrial Electronics Bulletin No. 12 and Annex B of ISO 4903.

X.26 (RS-423) specifies a single-ended unbalanced generator, connected to a balanced differential receiver by a single lead and a common return circuit. The basic circuit diagram is shown in figure 3. The specification also provides for controlled shaping of the generator output signal. This feature combined with the differential receiver provides superior noise performance over that of a true unbalanced single-ended configuration.

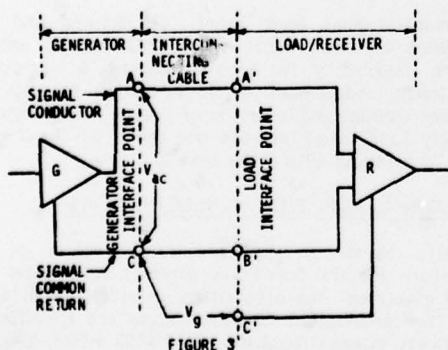


FIGURE 3
SYMBOLIC REPRESENTATION OF UNBALANCED CIRCUIT

X.27 (also designated as V.11) specifies balanced electrical characteristics essentially the same as EIA RS-422. Significantly superior performance up to 10 Mbit/s is provided using a balanced differential generator connected via a twisted cable pair to a balanced differential receiver. The symbolic circuit diagram is shown in figure 4. The differential receiver specification is identical to that of X.26 (RS-423). Therefore, with certain lead configurations, direct interoperability between X.26 and X.27 is possible.

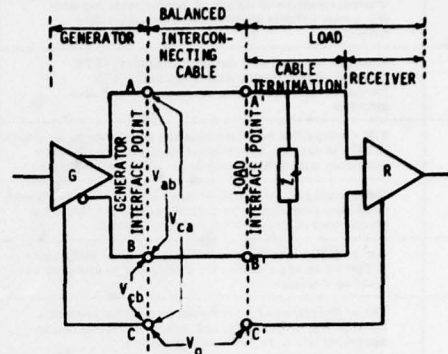


FIGURE 4
SYMBOLIC REPRESENTATION OF BALANCED CIRCUIT

Figure 5 illustrates the receiver configurations that apply to X.26 and X.27. Category 1 receivers have both input leads appearing at the interface while category 2 receivers have only one lead at the interface with the second lead connected to a common return circuit (Ga or Gb). Configuration 1A and 1B both utilize category 1 receivers. Either an X.26 or X.27 generator may be used. In configuration 2 only X.26 generators apply. This inherent flexibility designed into X.26 (RS-423) facilitates the orderly transition from V.28 (RS-232C) to the future utilization of X.27 (RS-422).

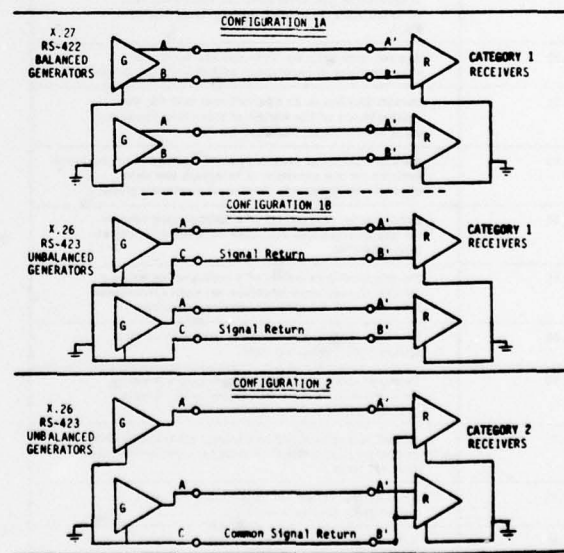


FIGURE 5
RECEIVER AND INTERCONNECTING CONFIGURATIONS

The mechanical characteristics specified by ISO DIS 4903 provide for a 15-pin connector from the same family of connectors of the commonly used 25-pin EIA RS-232C connector. All the interchange circuits specified by X.24 are accommodated. In addition, one pin is reserved for cable shield and one pin is spare. This automatically discourages any further proliferation of interchange circuits.

SPECIFIC INTERFACES

There are several different applications for which specific interfaces have been developed. Although there are a number of points of commonality between the applications, further work is required before a truly universal single interface will be realized. Each of the interfaces is briefly described to illustrate their characteristics and applications.

X.20 -

Recommendation X.20 applies to the interface between DTE and DCE for start-stop services including both circuit switched service and leased circuit service with either point-to-point or multipoint connections. Only the T and R data circuits apply together with appropriate signal return circuits from X.24 as shown in figure 6.

The electrical characteristic specification provides considerable flexibility for transition from existing equipment. The DCE is required to implement the unbalanced X.26 characteristics effectively using a category 1 receiver configuration. A DTE may use V.28, in case of existing equipment or either X.26 or X.27 in the case of new equipment. The ultimate objective is to evolve toward using all balanced X.27. The interoperability features built into X.26, as previously discussed, facilitates this evolution.

The user classes of signalling rates that apply to X.20 are identified in X.1 as classes 1 and 2. Class 1 specifies 300 bit/s, while class 2 specifies a range from 50 to 200 bit/s. All control signalling between the DTE and network must use International Alphabet No. 5 as specified by CCITT Recommendation V.3.

The character-oriented protocol for circuit establishment is specified by the Recommendation. It follows the typical phases of operation which are: QUIESCENT, CALL ESTABLISHMENT, DATA, DISCONNECTION. Associated state and timing diagrams are also provided by X.20.

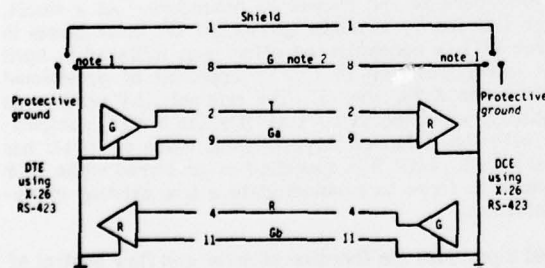


FIGURE 6

X.20 INTERCONNECTION CONFIGURATION FOR X.26 DTE - X.26 DCE

No requirements for start-stop public data network service have been identified in the USA. Germany, however, has been the principal supporter. It may also be implemented by Japan as well as a couple of other European countries.

X.20 bis -

At the time public data networks are initially implemented, terminals meeting the newly designed interfaces are not expected to be readily available. There are, however, many existing terminals in the field which operate with CCITT V.21 modems for start-stop operation. The interface for V.21 is very similar to EIA RS-232C. As an interim measure, X.20 bis was established to specify how new networks would interface and operate with V.21 compatible DTEs. This resolves the chicken and egg dilemma of which will come first, new networks or new terminals. X.20 bis facilitates this transition.

X.21 -

The interface, which has been a subject of considerable attention since 1969, is identified as the general purpose interface for synchronous operation. X.21 as well as X.20 serves to effectively define functions at all the three levels identified under the architecture. Operation of X.21 is for classes of service 3-7 as specified by X.1 for data signalling rates of 600, 2400, 4800, 9600, and 48,000 bit/s. It is also being adopted by ANSI as proposed American National Standard BSR X.3.69.

At level 1, all the functional circuits, except Gb, defined by X.24 are specified with application of the electrical characteristics of X.26 (RS-423) and X.27 (RS-422). The DCE is required to implement X.27 while the DTE may implement either X.26 or X.27. With the category 1 receiver configuration, full compatibility is realized regardless of which is implemented. Again, this is a feature for transition to the future.

A diagram showing the functional interchange circuits for X.21 is provided by figure 7. The states of each of the interchange circuits for the idle or quiescent conditions are basically defined as READY or NOT READY. This provides the simplest logic mechanism monitoring the DTE or DCE status as a level 1 function.

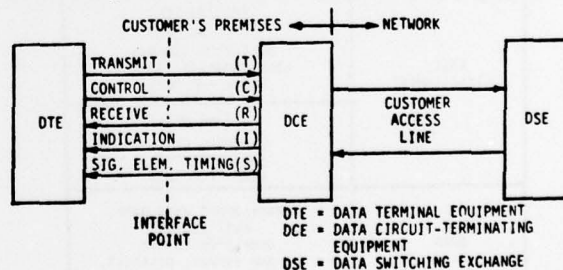


FIGURE 7
X.21 INTERFACE

In leased circuit operation, the simple, logical actions of changing the C and I circuits from OFF to ON serve as basic "wake-ups" to initiate data transfer between DTEs using a mutually agreed level 2 protocol.

X.21, as it is presently structured, is character-oriented using International Alphabet No. 5 (IA5) specified by CCITT Recommendation V.3. This is essentially the same as ASCII in the USA. The same basic four phases described under X.20 are followed by the X.21 procedure as shown in table 3. Also identified in table 3 are some representative states of the operating protocol. The logical function of the C circuit serves as the conventional on-off hook function. Such a simple, logical mechanism activates the more complex common equipment and shared processing resources. Similarly, the I circuit in the ON condition indicates to the DTE that a clear path is available for the DATA PHASE.

The circuit establishment protocol spans levels 2 and 3. The octet synchronizing mechanism at level 2 can be accomplished in one of two ways. The first method, which is to be available in all networks, utilizes the synchronization mechanism of two or more SYN characters preceding each signalling sequence. Each direction of transmission is independently synchronized this way. Some networks may offer an additional interchange circuit defined by X.24 as Byte Timing. A timing pulse which indicates octet boundaries is provided to the DTE by this circuit. The DTE uses the byte pulse to align the characters on both the R and T circuits. Thus synchronization of send information is dependent upon the received byte timing information. Simple odd parity is applied for the error control function at level 2.

Level 3 of X.21 for circuit switched applications is the CALL ESTABLISHMENT procedure. It is started with the ON condition of circuit C and terminated with the ON condition of circuit I. All control information during CALL ESTABLISHMENT is exchanged between the network and DTE on the R and T circuits in the form of IA5 characters and steady state conditions. The specifications provide comprehensive state and sequence timing diagrams to describe the operation.

TABLE 3
Phases Of Operation For X.21

Phases	States
QUIESCENT	NOT READY READY
CALL ESTABLISHMENT	calling end: CALL REQUEST SELECTION SIGNALS CALL PROGRESS SIGNALS READY FOR DATA
	called end: INCOMING CALL CALL ACCEPTED READY FOR DATA
DATA	Transparent data path, Full duplex, User free to use own format, protocol, and frame synchronization
DISCONNECTION	CLEAR REQUEST CLEAR CONFIRMATION

Implementation of the complete X.21 protocol is being done by the Nordic countries (Norway, Sweden, Finland, and Denmark) as well as Federal Republic of Germany and Japan. It is expected that more applications of X.21 will emerge in the future.

X.21 bis -

As previously explained under X.20 bis, terminals with the new interfaces will not likely be available at the time new data networks are implemented. Therefore, as an interim measure, the procedures in X.21 bis were developed to describe how a network should interface with existing DTEs which are defined for operation with synchronous modems meeting CCITT V-series Recommendations. These interfaces are very similar to the EIA RS-232C. It is expected that a USA standard like X.21 bis will not be needed. It will be up to individual networks to interface those existing RS-232C equipments available in the markets they are to serve. X.21 will then be provided as sufficient DTEs meeting the new interface become available.

X.25 - *

During the 1973-1976 CCITT study period, a rapporteur was assigned to study the subject of packet switching and recommend areas for standardization. This group drew considerable attention and made significant progress in their general studies. Near the end of their work, however, a greatly accelerated effort by the UK Post Office, French PTT, Bell Canada, and Telenet (USA) produced an interface proposal for virtual circuit operation over a packet switched network. With considerable political pressure through a number of participating nations, their proposal became approved as Recommendation X.25.

Virtual circuit service specified by X.25 provides a logical end-to-end path between terminals connected to the network. A virtual call establishes logical circuits as selected by a calling DTE and is held only for the duration of the communication. A provision is also made for permanent virtual circuits which provide an end-to-end connection for an indefinite period similar to leased circuit service. In this case, there are no call establishment and clearing procedures.

X.25 is defined in three levels as previously discussed under architecture. Level 1 specifies that either X.21 bis applies in the case of existing V-series DTEs or X.21 applies to new equipment. Only the level 1 portions of X.21 actually apply in this case.

At level 2, a link access procedure (LAP) is defined. Originally, as approved by CCITT September 1976, a procedure that used the principles of the ISO HDLC was specified. It turned out, however, that LAP was not fully compatible with HDLC in either the use of the elements of procedure or the classes of procedure. As a result, after ISO finally reached agreement on these issues in March 1977, a concentrated effort was initiated in April 1977 which resulted in CCITT approval of provisional revisions to X.25, level 2. The original LAP remains as originally specified, but a LAP B which is fully compatible with the Balanced Asynchronous mode of HDLC has been added. LAP B is specified as preferred while LAP remains in force to accommodate a few existing implementations.

Level 2 provides the function of error and flow control of the access link between the DTE and the network. Each frame has a check sequence to detect errors. Errored frames are retransmitted when requested by the receiving end. Flow control is accomplished through sending of

Receiver Ready (RR) commands or Receiver Not Ready (RNR) commands.

Level 3 of X.25 defines the packet formats and control procedures for exchange of information between a DTE and network. Establishment of a virtual circuit is initiated from a calling DTE by a Call Request packet. The called DTE is notified that a circuit is being established by an Incoming Call packet. The called DTE answers by returning a Call Accepted packet. Subsequently, the calling DTE is notified that the circuit is established by a Call Connected packet. Data packets are then exchanged between DTEs. Upon completion of the call, the circuit can be disconnected by either a DTE Clear Request packet or DCE Clear Indication packet, as appropriate, followed by a Clear Confirmation packet response.

The capability for multiplexing up to 4096 logical channels (virtual circuits) on single access link is also provided by X.25. Each logical channel can be used for virtual calls or a permanent virtual circuit. Each packet exchanged across the interface has its associated logical channel number identified. Each logical channel operates independently of the others. The data packets are also each identified by sequence numbers which are used for flow control of individual logical channels. RNR packets are used to stop transmission on a channel while RR packets permit transmission. The sequence numbering scheme may be based upon either modulo 8 for normal operation or modulo 128 for extended transmission delay conditions. The sequence numbers are then recycled every 8 or 128 packets, as appropriate.

Data packets are limited to a maximum data field length. All networks must allow a maximum of 128 octets, while some networks may also support maximum lengths of 16, 32, 64, 256, 512, and 1024 octets.

The format of the Call Request and Incoming Call packets is shown in figure 8. The Logical Channel Group

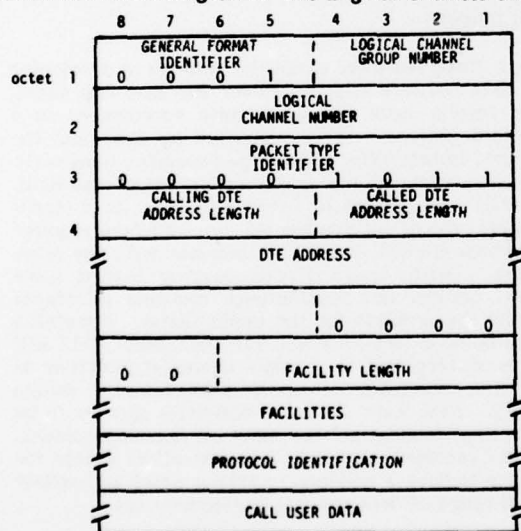


FIGURE 8

X.25 CALL REQUEST and INCOMING CALL Packet Format

Number and Logical Channel Number combined provide the identification of the logical channels. The General Format Identifier, in this case, designates Virtual Circuit Service. The Packet Type Identifier designates whether the packet is a Call Request, Call Accepted, Clear Request, etc. The address fields designate length and the calling address as well as the called address(s). Special service features requested for a particular call are included in the facilities field. Finally, the Call User Data field is supposed to be 16 octets reserved exclusively for end-to-end application of the user. This was changed somewhat by the recently approved X.29. The first four octets are now reserved for protocol identification for operation with a packet assembly/disassembly facility. The other packet type headers are considerably shorter containing only 3 to 5 octets to provide the essential information associated with the packet function.

As already mentioned, X.25 was developed with considerable haste to serve an apparent urgent need. Through both the panic of the closing 1973-1976 CCITT study period and political pressure for EUNET, no time was given to structuring X.25 to achieve any commonality with the X.21 circuit establishment protocol. Additionally, no consideration was given meeting more general purpose interfacing needs.

DATAGRAM - *

An intensive effort by ANSI resulted in the development of a proposed datagram interface for packet switched networks. Datagrams are defined as independent self-contained packets of data with all appropriate control and address information for the network to provide delivery to the destination. Unlike virtual call service, there are no call establishment or clearing procedures. Datagram service has a number of applications which can be handled more efficiently than virtual circuit operation. Examples include point-of-sale, funds transfer, credit checking, etc.

The interface specification that is being proposed internationally is both compatible with and complementary to X.25. This will enable equipment to implement datagram only, virtual call only, or both datagram and virtual call service over the same access link as shown in figure 9. Considerable work remains, but under the direction of a newly appointed CCITT Special Rapporteur, an agreed draft Recommendation is expected to be completed by spring 1980.

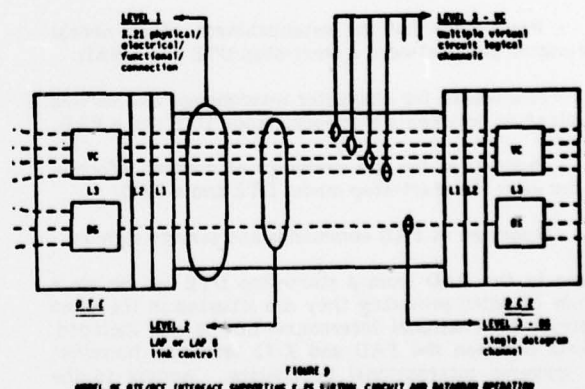


FIGURE 9

MODEL OF DTE/DCE INTERFACE SUPPORTING X.25 VIRTUAL CIRCUIT AND DATAGRAM OPERATION

*See NCS-TIB 79-4 draft Datagram procedures

X3, X.28, X.29 -

Subsequent to the establishment of X.25, another "urgent" need arose to define protocols for operation of start-stop character mode terminals with X.25 terminals. This resulted in the development of a packet assembly/disassembly facility (PAD) which would exchange serial data streams with the character mode terminal and packetize/depacketize the corresponding data exchanged with the X.25 terminal.

X.3 describes the basic functions and user selectable functions of the pad. In addition, the characteristics of pad parameters are given as well as their possible values.

The basic functions of the PAD include:

- Assembly of characters into packets destined for the X.25 DTE.
- Disassembly of the user data field of packets destined for the start-stop mode DTE.
- Handling of virtual call set-up and clearing, resetting and interrupt procedures.
- Generation of service signals.
- A mechanism for forwarding packets when the proper conditions exist, e.g., a packet is full or an idle timer expires.
- A mechanism for transmitting data characters, including start, stop, and parity elements as appropriate to the start-stop DTE.
- A mechanism for handling a "break" signal from the start-stop DTE.

User selectable functions which may be provided by the pad include:

- Management of the assembly and disassembly of packets.
- A limited number of additional functions related to the operational characteristics of the start-stop mode DTE.

The interface for the start-stop mode terminals accessing the PAD on a public data network is described by X.28. It specifies:

- Procedures for the establishment of an access information path between a start-stop DTE and a PAD.
- Procedures for character interchange and service initialization between a start-stop mode DTE and a PAD.
- Procedures for the exchange of control information between the start-stop mode, DTE and a PAD.
- Summary of PAD commands and service signals.

Access to the PAD from a start-stop DTE can be via a number of paths providing they are situated in the same country. International interconnection is not included. Packets between the PAD and X.25 terminal, however, may traverse international boundaries. Access to the

PAD from the start-stop mode DTE can be either through the public switched telephone network using leased voice lines with V-series interfaces (V.21), or public switched data networks using leased digital lines with X-series interfaces (X.20/X.21).

The procedures for the exchange of control information and user data between an X.25 DTE and a PAD are described by X.29. These are supplemental procedures to X.25 for the purpose of controlling and exchanging data with the PAD. An indicator called the data qualifier in the header of data packets is used to identify whether the data field contains user data to be passed to the character mode DTE or control information for the PAD. In the latter case, the information in the data field is not passed to the distant DTE by the PAD. At the present time, only the start-stop mode DTE can initiate a virtual call via the PAD. A number of additional items not covered by X.29 but identified for future study are:

- The possibility of a packet mode (X.25) DTE establishing a virtual call to a non-packet mode DTE.
- Use of a permanent virtual circuit facility.
- Interworking between non-packet mode DTEs on a packet switched transmission service.
- Interworking between DTEs having interfaces to different transmission services.
- Operation of non-packet mode DTEs in other than start-stop mode.

As with X.25, these three Recommendations were hastily put together leaving a considerable number of open-ended items for further study. Both editorially and technically, many revisions will be needed to facilitate a full understanding of the specifications and to ensure that implementations will work among all DTEs and networks meeting these interfaces.

CONCLUSIONS -

Although there has been extensive activity in developing public data network standards over the past few years, all the results have not been fully coordinated in a harmonious picture. As exemplified by X.25 and the PAD work, instant efforts developed specifications without consideration of the impact on existing standards, the overall architecture or future systems. As it stands now, each type of service has its own interface requirements which are not necessarily common with any other interface. With design trends heading toward more universal designs and applications, multiple interfaces compound the problem for the implementer. Hopefully, the continuing efforts in ANSI, EIA, ISO, and CCITT will direct a convergence to a single universal interface to satisfy the spectrum of needs with minimal design difficulty. New work in these activities appears to be the starting foundation for such an accomplishment. Little has yet been agreed in this new effort except for the desire to have a common interface which will satisfy the total range of data communication services.

A P P E N D I X

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